

Improved Engineering Analysis for GOES-R

Engineering Analysis (EA) is more than just a plotting program.
EA encompasses both Trending and Analysis – Two very different paradigms.

Trending

The **comprehensive** review of telemetry to:

- Observe changes in nominal behavior and detect impending failures
- Quantify and track expected changes in spacecraft characteristics (e.g. mass properties modeling)
- Quantify periodic variations so that they can be optionally removed in order to observe residual behavior

Proactive — Comprehensive — Predictive — Automated

Analysis

The **targeted** review of telemetry to:

- Identify
- Characterize
- Explain and
- Workaround

An observed anomaly or failure in a timely fashion.

Reactive — Targeted — Investigative — Interactive

How can such diverse requirements be met in a safe and cost effective way?

A mission needs a telemetry system designed for analysis!

GOES-R integrates the (COTS) CASSIE™ Telemetry System for a low cost, highly flexible solution.

Independent Decommutation

Traditionally, the telemetry processor in a spacecraft command and control system is the common access point for most mission health and status data. The purpose of this decommutation engine is to unpack and calibrate discrete measurements from a binary data stream, time-correlate the samples, and then pass that information to client applications. For real-time command systems that care about the here-and-now, this is exactly what is needed.

In contrast, analysis is interested in the past, present, and future. The targeted review of past data is necessary for any anomaly investigation. The comprehensive processing of past data is necessary to anticipate future behavior. Finally, processing data in near real-time while applying advanced mathematics functions can extend the command system's capabilities beyond the basic design.

However, decommutation is an “explosive,” one-way process. Once executed, even the simple act of collecting a handful of measurements from a central archive, resolving time differences, and interleaving values to reconstruct the event can be tedious. The comprehensive review of thousands of measurements over days, months, and years may seem unobtainable in many circumstances. Some analysis systems attempt to compensate by statistically summarizing measurements “on-the-fly,” but are faced with bandwidth limitations and processing bottlenecks.

Considering that raw telemetry frames already pack the most information in the smallest storage size and maintain the best available estimate of time correlation, it follows that an analysis system should operate in these data directly. Given the nature of telemetry and the need for analysis to span all time periods, the solution begins with an independent decommutation engine.

The CASSIE™ Telemetry System from Astrofrontiers, Inc. is one such solution. Offered as a Commercial Off-the-Shelf (COTS) product, CASSIE provides a highly efficient, independent decommutation engine. Once liberated from the command system's central access point, the necessary processing can be distributed over many platforms and in many locations making the solution naturally scalable!

The benefits of independent decommutation manifest in many other ways. Since the source data is naturally compact, a solution can be small and portable. No large, expensive, central database server is necessary. No need to store terabytes of CSV data. Just process the telemetry frames from the archive on your transportable drive.

Also, a telemetry frame is just a frame no matter where or when it is received. A telemetry-aware CASSIE application can be pointed at a live data stream for real-time monitoring as easily as it can be directed to an archive and allowed to process data as fast as the computer can run. One visualization can be applied across the entire operations lifecycle thus providing unprecedented flexibility.

Analysis is complex by its nature and as anyone who has been involved with space missions will tell you, “Every mission is different.” Therefore, the analysis solution must allow for the integration of mission-specific functionality. To this end, CASSIE provides a number of features including:

- An application infrastructure to manage common tasks such as logging, memory management, and configuration management.
- Run-time loadable modules that can manage data streams, process telemetry on the fly, and publish new telemetry values.
- Access to libraries and header files so that mission specific applications can be crafted.

The CASSIE system provides a large percentage of mission capability out-of-the-box, but also includes the necessary extensibility to complete the picture.

CASSIE is not a single, monolithic program like word processors or spreadsheets. Rather it is a system of applications, libraries, and modules that can be used both interactively and in batch processing. Routine, monotonous tasks can be bundled into automated processing while still allowing operators to launch interactive viewers for monitoring and anomaly investigation.

CASSIE's unique design, high performance telemetry engine, and expandability bring together the diverse requirements of both trending and analysis.

GOES-R Integration

ASRC Federal Space and Defense is currently integrating the CASSIE™ Telemetry System into the GOES-R ground system. Mission Operations will span several physical locations and several logical, security zones.

Within the primary zone, CASSIE data management programs will routinely extract Space Packets from the host ground system, sort those data into time-ordered, non-redundant data sets and then store the data into a growing mission archive. The archive is entirely file based and composed of portable “chunks” that are replicated to other locations and zones within the ground system. Operators can copy subsets of the archive for portable or remote analysis.

In addition to the data management processes, CASSIE will provide near real-time telemetry relay to local workstations so that CASSIE applications and analysis programs can support on-going operations. Since CASSIE can apply advanced mathematical operations “on-the-fly”, this mode of operation will extend and enhance the capabilities of the ground system's command and telemetry components.

Most CASSIE applications can be executed both interactively and in a headless, batched mode. Several production tasks will be scripted to routinely generate products including statistical summary data, subsystem profile plots in a printable format, long-term trend plots, and any number of mission specific products. Thousands of measurements can be loaded into a single CASSIE instance to generate periodic statistical data for long-term trending.

Finally, since the system works on the packet level, there is very little that cannot be created or re-created after the fact. Existing missions can still reap the benefits of the CASSIE Telemetry System well after launch.

Remote Access Solved!

A new telemetry limit violation is detected by console operators, but subsystem experts are at home or on travel. What can be done? This sets up the traditional battle between spacecraft safety and ground segment security. Allowing external users to penetrate boundaries to reach internal sources of telemetry data is often deemed too risky and can be disallowed.

By providing a portable, independent decommutation engine hosted on encrypted partitions or virtual machines, remote access transforms into remote processing. A subtle, but important difference in that the latter only requires that authorized users reach the boundary of the security zone to request real-time data streams or to download recently archived telemetry. This “thick client” approach also affords the greatest processing power and the ability to operate the analysis system wherever the system experts happen to be.

Visualization

Display integration is useful and necessary, but sometimes it can be a mess. All-in-one displays that combine text, plots, and line graphics into one window can provide mixed results: fonts are often disparate and text misaligned; plotting widgets can be too small; line graphics can be difficult to specify and connect. Alternatively, CASSIE™ provides a dedicated app for each type of visualization:

- A plotting application that provides a clear, detailed, and accurate data representation that can be viewed interactively as well as spooled off to printable files (e.g. pdf, png, and postscript).
- A text-engine embedded in an application to stream text, text tables (CSVs), and produce text-oriented display pages that can be “snapped” to small .txt files rather than large graphic images.
- The basics of three dimensional visualization are provided so that all team members can benefit from this highly visual and intuitive view.
- An application that can ingest an annotated, scalable vector graphics (SVG) image and then drive color and style characteristics based upon telemetry values.

